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STUDIES ON THE ALTERATIONS IN BLOOD SUGAR AND RUMEN FLUID FOLLOWING PERORAL ADMINISTRATION OF READILY AVAILABLE CARBOHYDRATES TO DAIRY COWS

By

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The energy requirements of dairy cows are met mostly by the volatile fatty acids formed by digestion in the rumen. The soluble carbohydrates in the fodder are converted chiefly to acetic acid, propionic acid and butyric acid in the rumen, and only insignificant quantities of soluble carbohydrates are resorbed as such in conventional rations (*Lindsay* 1959; *Bartley & Black* 1966). The metabolic need for glucose in the cow is met almost exclusively from endogenous sources, especially through glyconeogenesis from propionate formed in the rumen. Ruminants possess the same ability as non-ruminants, however, to metabolize glucose absorbed from the digestive tract (*Armstrong et al.* 1957; *Bartley & Black*).

Owing to the disruptive effect of the rumen flora on carbohydrates, non-carbohydrates — e.g. Na-propionate and propylene glycol — have usually been employed as a therapeutic means of raising the blood sugar level of cows (*Schultz* 1952; *Waldo & Schultz* 1960). But the blood sugar level of cows can also be raised by very large peroral sugar rations, presumably because some sugar then escapes ruminal fermentation and passes to the abomasum and small intestine, where it is quickly resorbed. *Hodgson et al.* (1932), for instance, gave 3—4 kg glucose to normal cows and found heavy rises of blood sugar with maximal

effect after about 2 hrs., while *Shaw et al.* (1942) gave up to 3 kg of glucose to ketotic cows with moderate rises as a result. After a peroral glucose dose of 4.5 g/kg body weight *Holmes* (1952) found a moderate, and after 9 g/kg a heavy, rise of blood sugar. With lower doses (1 and 2 g/kg body weight) neither *Bell & Jones* (1945) nor *Holmes* found any marked rise of blood sugar.

Riek (1954) found a heavier rise in blood sugar in calves, if a 10 % solution of $NaHCO_3$ was given immediately before a peroral glucose dose than if glucose was administered alone. This is because certain Na salts give rise to closure of the oesophageal groove whereby liquid food is transferred to the abomasum without first passing through the rumen. In young animals the oesophageal groove reflex is elicited very easily. With rising age the reflex is considerably harder to release, but in older animals as well a certain reaction generally persists, if the stimulus is sufficiently powerful. Considerable individual variations appear to exist so that the closure of the oesophageal groove may easily be released in some elderly cows (*Wester* 1930).

The effect of peroral sugar administration on the composition of the rumen flora and fluid appears to be greatly dependent on the size of the dose and on whether the administration is continuous or as a single dose. If the sugar is given in small or moderate doses, one may expect a slight and quickly compensated drop in pH and an increased production of volatile fatty acids (*Purser & Moir* 1959; *Krogh* 1959, 1960). If the sugar is administered without prior habituation and in very large doses, there is a heavy drop in pH and a radical change in composition of the rumen flora, i.e. an acid indigestion occurs which may be fatal (*Krogh* 1959, 1960). The experiments referred to were made on sheep. In dairy cows depressed appetite and diarrhoea have been reported after peroral glucose doses, but only when the doses have exceeded 3 kg (*Shaw et al.; Holmes*).

The composition of the rumen fluid is affected also by the type of sugar administered. *Martin & Wing* (1966) found that the molar proportions of the volatile fatty acids did not change, if molasses (chiefly saccharose) were added to the ration, while *Huber et al.* (1967) showed that the percentage of butyric acid rose and of propionic acid fell, if the ration included whey. *Phillipson & McAnally* (1942) and *Krogh* (1960) found that lactose is decomposed more slowly in the rumen than, for example, saccharose.

No experiments in peroral administration of fructose to dairy cows have been found in the literature. There are several reports of favourable therapeutic results of fructose administration in different metabolic disorders in man (see *Leuthardt* 1960). The reason for this is that the fructose metabolism, compared with the glucose metabolism, is characterized by certain peculiarities (*Leuthardt; Velle* 1964). For example fructose is metabolized much more quickly than glucose in the liver, while the reverse applies in the musculature, and furthermore a diabetic is well able to metabolize fructose but not glucose.

The object of the present study was:

1) to investigate whether the resorption of sugar also in the dairy cow increases, if $NaHCO_3$ is given before the sugar in order to release the oesophageal groove reflex,
2) to compare the effect on blood sugar level and ruminal digestion of glucose and fructose administered perorally with $NaHCO_3$ as prior dose,
3) to compare the effect on blood sugar level and ruminal digestion of molasses (saccharose) and whey (lactose).

MATERIAL AND METHODS

Experiment I. Twelve clinically healthy Swedish Red and White cows aged 3—11 years and in varying stages of lactation were given 750 g of glucose and 35 g of $NaHCO_3$ + 750 g of glucose perorally on different occasions about 2 hrs. after the start of the morning feed. At least one and at most three weeks elapsed between the two administrations. On the first occasion half of the cows were given glucose and half $NaHCO_3$ + glucose. The glucose was dissolved in 2 l of water and the $NaHCO_3$ in 350 ml of water prior to the administration, which was by bottle. About ½ min. elapsed between the administration of $NaHCO_3$ and of glucose. Blood samples for determination of reducing substance by the Hagedorn-Jensen method, hereinafter called blood sugar, were taken immediately before (0 hr.) and ½, 1, 2, 4 and 6 hrs. after the administration. The afternoon feed was given about 5 hrs. after the administration of the respective substances.

Experiment II. This experiment, made one year later, comprised 12 clinically healthy Swedish Red and White cows 3—12 years of age and in varying stages of lactation. The feeding routine

was the same as in experiment I. The animals were given in the same way and at the same time $NaHCO_3$ + glucose (35 + 750 g) and $NaHCO_3$ + fructose (35 + 750 g). Blood samples were taken immediately prior to the administration and 1, 2, 6, 12 and 24 hrs. after. In addition to blood sugar by the Hagedorn-Jensen method, determinations were also made of blood glucose (with glucose oxidase reagent). Rumen samples were taken with a stomach tube immediately before (0 hr.) and 1 and 2 hrs. after the administration of the respective substances. Rumen pH was measured with a pH meter and volatile fatty acids (VFA) by gas chromatography (*Carlström et al.* 1965). The same series of tests were made on a later occasion on the same 12 cows without any treatment (control group). Rumen samples were taken from only 10 cows, however, in the control group.

Experiment III. The same cows were used in this experiment as in experiment II. They were given perorally about 1500 g of molasses (corresponding to about 750 g of saccharose) and 1800 g of a whey concentrate (corresponding to about 750 g of lactose). The sampling procedure was the same as in experiment II with the exception that rumen samples were taken also immediately before the afternoon feed about 5 hrs. after the administration of molasses and whey. The same control group was used in experiments II and III.

In all experiments the tabulated values are based on the percentage increase or decrease in relation to the value at the 0-hr. sampling. The amounts of total volatile fatty acids (total VFA), acetic acid (HAc), propionic acid (HPr) and butyric acid (HBu) in the rumen content were calculated as meq./l. For different reasons occasional samples could not be analysed (Tables 3 and 5).

RESULTS

Analyses of variance which are not tabulated, showed that no significant daily variation existed for blood sugar and blood glucose at the times of the tests (0 hr., +1, +2, +6, +12, +24, see Tables 2 and 4). As regards the composition of the rumen fluid, on the other hand, there was a statistically significant variation between the times of sampling (0 hr., +1, +2, +5, see Table 5) for all factors (pH, total VFA, HAc, HPr, HBu).

Table 1. Percentage change from original value (0 hr.) of blood sugar after administration of $NaHCO_3$ + glucose and glucose. n=12.

	+ ½ hr.		+ 1 hr.		+ 2 hrs.	
	$NaHCO_3$ + glucose	Glucose	$NaHCO_3$ + glucose	Glucose	$NaHCO_3$ + glucose	Glucose
$\bar{x}$	+16.0	+8.5	+23.3	+9.5	+25.7	+11.4
s	14.1	5.8	24.5	9.2	22.9	13.2
t	1.71		1.94		1.87	

Table 1 (continued).

	+ 4 hrs.		+ 6 hrs.	
	$NaHCO_3$ + glucose	Glucose	$NaHCO_3$ + glucose	Glucose
$\bar{x}$	+16.4	+12.0	+10.5	+7.0
s	11.6	11.3	9.4	13.2
t	0.95		0.72	

Experiment I. No clinically observable symptoms occurred in the cows tested.

As is seen from Table 1, the variations within the material were so great that no significant differences existed between the groups, although the numerical differences between the mean values were fairly large. There was, however, a clear tendency to a greater increase in blood sugar after ½, 1 and 2 hrs. when the $NaHCO_3$ solution was given before the glucose.

Experiment II. No clinical symptoms were observed in the cows after administration of $NaHCO_3$ + glucose. Eight of the cows had severe diarrhoea 5—12 hrs. after being given $NaHCO_3$ + fructose. A day later they had fully recovered.

As appears from Table 2, neither blood sugar nor blood glucose levels were significantly affected by the administration of $NaHCO_3$ + fructose, but the values rose after $NaHCO_3$ + glucose, significantly for blood sugar after 1, 2, 12 and 24 hrs. and for blood glucose after 1 and 2 hrs. After 12 and 24 hrs. the blood glucose value as well had risen considerably, though not significantly. Six hrs. after the administration there was no pronounced change in the blood sugar or blood glucose levels, neither after glucose nor fructose.

The rumen tests are presented in Table 3. Both $NaHCO_3$ +

Table 2. Percentage change from original value (0 hr.) of blood sugar and blood glucose after administration of $NaHCO_3$ + glucose and $NaHCO_3$ + fructose. Mean ± standard deviation.

	Time	A $NaHCO_3$ + glucose n = 12	B $NaHCO_3$ + fructose n = 12	C Daily variation n = 12	Comparison A—B	Comparison A—C	Comparison B—C
Blood sugar	+ 1	+ 8.5 ± 9.9	— 5.4 ± 6.9	— 3.6 ± 8.1	***)	**)	n. s.
	+ 2	+11.3 ± 12.3	— 1.2 ± 7.9	+ 0.8 ± 2.7	**)	**)	n. s.
	+ 6	+ 4.9 ± 12.6	+ 3.2 ± 9.8	+ 1.5 ± 5.5	n. s.	n. s.	n. s.
	+12	+13.4 ± 12.8	+ 9.8 ± 9.7	+ 3.6 ± 7.6	n. s.	*)	n. s.
	+24	+ 7.0 ± 10.1	+ 2.9 ± 10.5	— 1.4 ± 8.0	n. s.	*)	n. s.
Blood glucose	+ 1	+25.5 ± 23.5	— 4.0 ± 11.0	+ 1.4 ± 10.2	***)	**)	n. s.
	+ 2	+24.0 ± 21.8	— 2.2 ± 13.9	+ 7.3 ± 10.0	**)	*)	n. s.
	+ 6	+ 4.6 ± 16.7	+ 4.5 ± 20.8	+ 9.4 ± 13.6	n. s.	n. s.	n. s.
	+12	+18.6 ± 20.3	+ 6.6 ± 19.3	+ 7.3 ± 16.9	n. s.	n. s.	n. s.
	+24	+ 5.6 ± 14.7	— 1.6 ± 13.6	— 2.4 ± 13.6	n. s.	n. s.	n. s.

n. s. = not significant
*) $0.05 > P > 0.01$
**) $0.01 > P > 0.001$
***) $0.001 > P$

Table 3. Percentage change from original value (0 hr.) in composition of rumen fluid after administration of $NaHCO_3$ + glucose and $NaHCO_3$ + fructose. Mean ± standard deviation.

	Time	A $NaHCO_3$ + glucose n = 12	B $NaHCO_3$ + fructose n = 11	C Daily variation n = 10	Comparison A—B	Comparison A—C	Comparison B—C
pH	+ 1	— 0.3 ± 3.6	— 4.1 ± 4.2	+ 2.2 ± 1.7[a]	*)	n. s.	**)
	+ 2	+ 2.8 ± 5.3	— 1.2 ± 10.8[b]	+ 4.3 ± 3.2[a]	*)	n. s.	**)
Total VFA	+ 1	+ 5.0 ± 12.1	+ 5.2 ± 12.8[c]	— 6.8 ± 9.2	n. s.	*)	*)
	+ 2	+ 2.6 ± 10.0	+ 2.5 ± 9.9	—15.0 ± 8.2	n. s.	***)	***)
HAc	+ 1	+ 2.5 ± 12.9	+ 2.1 ± 12.5[c]	— 6.5 ± 10.3	n. s.	n. s.	n. s.
	+ 2	+ 1.0 ± 12.2	+ 0.9 ± 9.3	—11.8 ± 11.1	n. s.	*)	**)
HPr	+ 1	+ 6.8 ± 12.5	+11.9 ± 20.3[c]	—10.5 ± 10.8	n. s.	**)	**)
	+ 2	+ 2.5 ± 13.5	+ 3.4 ± 16.2	—26.1 ± 7.9	n. s.	***)	***)
HBu	+ 1	+13.1 ± 13.6	+11.3 ± 17.1[c]	— 1.9 ± 10.0	n. s.	**)	*)
	+ 2	+12.4 ± 17.2	+11.0 ± 16.5	—13.0 ± 9.3	n. s.	***)	***)
		[a] n=8	[b] n=12	[c] n=10			

n. s. = not significant
*) $0.05 > P > 0.01$
**) $0.01 > P > 0.001$
***) $0.001 > P$

Table 4. Percentage change from original value (0 hr.) of blood sugar and blood glucose after administration of molasses and whey. Mean ± standard deviation.

	Time	A Molasses n = 12	B Whey n = 12	C Daily variation n = 12	Comparison A—B	Comparison A—C	Comparison B—C
Blood sugar	+ 1	+ 2.0 ± 8.3	+ 3.9 ± 6.7	— 3.6 ± 8.1	n. s.	n. s.	*)
	+ 2	+ 4.7 ± 7.8	+ 3.0 ± 7.9	+ 0.8 ± 2.7	n. s.	n. s.	n. s.
	+ 6	+13.0 ± 6.3	+ 2.1 ± 4.8	+ 1.5 ± 5.5	***)	***)	n. s.
	+12	+20.3 ± 10.7	+ 8.2 ± 6.1	+ 3.6 ± 7.6	**)	***)	n. s.
	+24	+ 8.9 ± 11.4	+ 4.1 ± 9.8	— 1.4 ± 8.0	n. s.	*)	n. s.
Blood glucose	+ 1	+ 3.8 ± 14.1	+ 5.2 ± 10.8	+ 1.4 ± 10.2	n. s.	n. s.	n. s.
	+ 2	+ 9.9 ± 13.3	+ 6.7 ± 12.6	+ 7.3 ± 10.0	n. s.	n. s.	n. s.
	+ 6	+20.5 ± 18.5	+11.2 ± 10.9	+ 9.4 ± 13.6	n. s.	n. s.	n. s.
	+12	+26.6 ± 25.6	+16.7 ± 11.1	+ 7.3 ± 16.9	n. s.	*)	n. s.
	+24	+12.7 ± 25.2	+ 4.1 ± 14.4	— 2.4 ± 13.6	n. s.	n. s.	n. s.

n. s. = not significant
*) $0.05 > P > 0.01$
**) $0.01 > P > 0.001$
***) $0.001 > P$

Table 5. Percentage change from original value (0 hr.) in composition of rumen fluid after administration of molasses and whey. Mean ± standard deviation.

	Time	A Molasses n = 12	B Whey n = 12	C Daily variation n = 10	Comparison A—B	Comparison A—C	Comparison B—C
pH	+ 1	— 2.4 ± 3.9	— 4.9 ± 2.2	+ 2.2 ± 1.7[a]	n. s.	**)	***)
	+ 2	+ 0.8 ± 3.4	— 0.5 ± 3.0	+ 4.3 ± 3.2[a]	n. s.	*)	**)
	+ 5	+ 4.6 ± 5.2	+ 1.1 ± 3.3	+ 5.9 ± 6.2[a]	n. s.	n. s.	*)
Total VFA	+ 1	+ 3.6 ± 11.5	+19.2 ± 14.6	— 6.8 ± 9.2	**)	*)	***)
	+ 2	— 0.9 ± 13.3	+12.7 ± 16.2	—15.0 ± 8.2	*)	**)	***)
	+ 5	—11.4 ± 11.6	+ 4.0 ± 14.6	—11.0 ± 11.2	**)	n. s.	*)
HAc	+ 1	+ 1.8 ± 10.6	+21.7 ± 15.9	— 6.5 ± 10.3	**)	n. s.	***)
	+ 2	— 2.6 ± 15.0	+16.9 ± 18.6	—11.8 ± 11.1	**)	n. s.	***)
	+ 5	— 9.4 ± 12.3	+ 7.6 ± 15.3	— 6.1 ± 11.7	**)	n. s.	*)
HPr	+ 1	+ 9.3 ± 12.1	+ 9.1 ± 15.4	—10.5 ± 10.8	n. s.	***)	***)
	+ 2	+ 1.2 ± 12.2	— 2.0 ± 13.2	—26.1 ± 7.9	n. s.	***)	***)
	+ 5	—17.2 ± 11.2	— 9.8 ± 14.5	—23.5 ± 11.2	n. s.	n. s.	*)
HBu	+ 1	+ 9.9 ± 16.0	+21.3 ± 15.5	— 1.9 ± 10.0	n. s.	*)	***)
	+ 2	+ 6.5 ± 12.4	+15.2 ± 19.3	—13.0 ± 9.3	n. s.	***)	***)
	+ 5	—10.3 ± 13.3	+ 9.8 ± 19.8	—15.6 ± 13.3	**)	n. s.	**)

[a] n = 8

n. s. = not significant
*) $0.05 > P > 0.01$
**) $0.01 > P > 0.001$
***) $0.001 > P$

glucose and $NaHCO_3$ + fructose gave rise to pronounced changes in the composition of the rumen fluid. The total content of VFA and the contents of all acids rose, the increase being percentually rather greater for HPr and HBu than for HAc. Fructose produced a significantly lower rumen pH than glucose. Otherwise the changes in composition of the rumen fluid after administration of fructose and glucose seem to have been similar qualitatively and quantitatively.

Experiment III. No clinically observable symptoms occurred in this experiment.

Molasses caused a significant rise in blood sugar 6, 12 and 24 hrs. after administration (Table 4). The blood glucose level as well increased markedly at these times, although significantly only after 12 hrs. No significant rise of blood sugar or blood glucose was recorded 1 and 2 hrs. after feeding with molasses.

The cows given whey had with one exception (blood glucose at +2 hrs.) somewhat higher blood sugar and blood glucose values than the control group. A significant difference, however, was recorded only on one occasion (blood sugar at +1 hr.). The rises measured after 6, 12 and 24 hrs. in the whey group were throughout considerably smaller than in the molasses group.

It will be seen from Table 5 that the composition of the rumen fluid was markedly affected by the administration of molasses and whey. The effect was constantly greater 1 and 2 hrs. than it was 5 hrs. after administration. At the latter time the differences between the molasses group and the control group had evened out, while significant changes still persisted in the cows which had received whey.

Both molasses and whey caused a lowering of rumen pH and a rise of total VFA 1 and 2 hrs. after administration. The contents of the individual acids also increased in both cases and at the same time, but a significant difference was not found for HAc in the comparison between the molasses group and the control group.

After the whey dose the values of total VFA, HAc and HBu were considerably higher at all times than after molasses. As regards HPr there were no significant differences between the molasses and whey groups. Rumen pH was rather lower after whey than after molasses, though the differences were not significant.

DISCUSSION

As appears from the magnitude of the standard deviations (Tables 1—5) there were very great variations within the material in all experiments. This may be explained by the fact that the individual cows within the groups were in varying stages of lactation and therefore received different amounts of fodder. Probably, furthermore, there are variations in the speed with which readily available energy products (VFA, sugar) are resorbed and metabolized in cows in different stages of lactation, which should have contributed to the large scatter in the experiments.

The manifest tendency to improved glucose resorption in experiment I, when 10 % $NaHCO_3$ solution was given immediately prior to the glucose, appears to confirm that even in adult cattle the oesophageal groove reflex can be released, if the stimulus is sufficiently strong (*Wester* 1930). *Riek* (1954) has earlier shown that in the calf the blood sugar level rises more, when $NaHCO_3$ is given before a peroral dose of glucose than when the glucose is given without such predosage. The same appears to apply to the cow.

The increase of VFA shown in Table 3 indicates that, despite the administration of $NaHCO_3$, relatively large quantities of glucose (and fructose) found their way into the rumen. This is supported by the fact that the measured rise in blood sugar and blood glucose was only slight. For *Bartley & Black* (1966) found a larger rise in blood sugar when a comparable quantity of glucose was directly infused into the duodenum. On the other hand, according to the stage of lactation and the energy requirement, variations may be considered to exist as regards the speed at which the liver metabolizes glucose, so that an investigation of jugular blood does not necessarily tell anything about the amount of glucose resorption from the intestine. To get a more definite idea of this glucose resorption, continuous measurements of glucose are required also in blood from the portal vein.

Table 1 shows that peroral administration of only 750 g of glucose resulted in a certain rise in blood sugar. The changes were numerically rather greater than, though not significantly different from, those which occurred when the same cows received no treatment (not recorded). This agrees with results from earlier experiments (*Bell & Jones* 1945; *Holmes* 1952), in which

no or only an insignificant rise in blood sugar occurred after peroral doses of glucose of 1—2 g per kg body weight.

Fructose is metabolized considerably more quickly than glucose in the liver (*Leuthardt* 1960). For this reason it is not impossible that fructose may to some extent have been resorbed from the abomasum — duodenum in experiment II, thereafter being so quickly metabolized by the liver that no rise in blood sugar or blood glucose was found in jugular blood at the times in question. The severe diarrhoea which occurred in two thirds of the cows after administration of $NaHCO_3$ + fructose, however, suggests that the fructose partially passed through the gastrointestinal tract unutilized. On the basis of the present material, accordingly, it does not appear suitable to give fructose perorally to dairy cows.

After administration of $NaHCO_3$ + glucose there was a diphasic rise in blood sugar and blood glucose (Table 2). The first rise (after 1 and 2 hrs.) can be explained by a direct resorption of glucose from abomasum — small intestine while the second (after 12 and 24 hrs.) probably indicates that it takes some time for the liver to convert glycogenic substances formed in the rumen into glucose. A hormonally regulated feedback mechanism is also conceivable, for example a certain incretion of insulin following the first rise of glucose. In either case it appears that one can count on a persistent effect on the blood sugar picture for about 24 hrs. after a ration of $NaHCO_3$ + glucose.

A single dose of molasses was followed by a rise in blood sugar and blood glucose after 6, 12 and 24 hrs., while no definite effect was found after 1 and 2 hrs. (Table 4). This indicates that the molasses were predominantly broken down into VFA in the rumen. The rise was probably due to a glyconeogenesis in the liver from glycogenic substances (especially propionate) formed in the rumen.

According to *Martin & Wing* (1966) the molar proportions of the various fatty acids in the rumen are unaffected when molasses are added to the ration. These findings are confirmed by the present study. Obviously the molasses were quickly broken down in the rumen as there was no marked difference in composition of the rumen fluid between the molasses group and control group 5 hrs. after the administration. The whey group differed in this respect, since the changes in the ruminal digestion were still present at that time. This suggests a relatively slow breakdown

of whey, which agrees with the reports of *Phillipson & McAnally* (1942) and *Krogh* (1960) that lactose is converted more slowly than saccharose in the rumen.

Bowman & Huber (1967) found that an addition of lactose to the ration resulted in an increased production of HBu and reduced production of HAc in the rumen. In the present study whey caused a heavy rise both of HAc and HBu. The reason for the lack of agreement in the experimental results may be that the doses and mode of administration differed. *Bowman & Huber* and *Huber et al.* (1967) reported a favourable effect of the addition of lactose and whey, respectively, on the milk fat content. As additions of HAc and HBu are reported to raise the fat content (*Rook & Balch* 1961), it may be presumed that the whey concentrate used by us should have a potentially positive effect on the milk fat content.

Although molasses and whey gave rise to a similar increase of HPr production in the rumen, the blood sugar and blood glucose values rose more after the molasses than after the whey. This can hardly be explained by the slow breakdown of whey with consequently delayed resorption of glycogenic substances, since the blood sugar and blood glucose contents remained higher in the molasses group 12 and 24 hrs. after the administration. The reason may instead be that the fatty acid mixture formed in the rumen by the breakdown of the whey was more "ketogenic" in composition (cf. *Simkins et al.* 1965).

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SUMMARY

After peroral administration of 10 % $NaHCO_3$ solution + glucose the rise in blood sugar was greater than after glucose alone. This indicates that the oesophageal groove reflex can be released also in adult cattle. By this means part of the glucose administered probably passed direct to the abomasum — small intestine without first being converted into volatile fatty acids in the rumen. The blood sugar rise was diphasic, the first coming after 1 and 2 hrs. and the second after 12 and 24 hrs. Six hrs. after the ration there was no rise. After administration of $NaHCO_3$ + fructose most of the cows had severe diarrhoea and the blood sugar value was unaffected. The changes in composition of the rumen fluid after $NaHCO_3$ + glucose and after $NaHCO_3$ + fructose were similar with the exception that the rumen pH was lower after the fructose ration.

In another experiment a comparison was made between the effects on blood sugar level and rumen fluid of molasses (saccharose) and whey (lactose) administered perorally. Molasses caused a manifest rise in blood sugar 6, 12 and 24 hrs. after the administration, whereas after whey the blood sugar level had risen only slightly at the same time. The molasses were quickly converted in the rumen, and the molar proportions of the volatile fatty acids formed were unaffected. The whey was broken down considerably more slowly and under formation of considerably more HAc and HBu than in the case of molasses. This is interpreted in the manner that the whey concentrate used should have a potentially positive effect on the milk fat content.

ZUSAMMENFASSUNG

Der Effekt peroral verabreichter, leicht löslicher Kohlenhydrate auf die Verdauung im Pansen und auf das Blutzuckergehalt der Milchkühe.

Eine perorale Verabreichung 10 %-iger $NaHCO_3$-Lösung + Glukose bewirkte eine grössere Steigerung des Blutzuckergehalts als reine Glukose. Dies deutet darauf hin, dass der Schlundrinnenreflex auch bei erwachsenen Rindern ausgelöst werden kann. Ein Teil der Glukose wurde dadurch wahrscheinlich direkt in den Labmagen und Dünndarm geführt, ohne sich zuerst im Pansen in flüchtige Fettsäuren umzuwandeln. Die Erhöhung des Blutzuckergehalts war diphasisch mit der ersten Steigerung nach 1 und 2 Stunden und der anderen nach 12 und 24 Stunden. Sechs Stunden nach der Verabreichung war keine Erhöhung vorhanden. Nach $NaHCO_3$ + Fruktose bekamen die meisten Kühe heftigen Durchfall und deren Blutzuckerwert wurde nicht beeinflusst. Die Veränderungen, die in der Zusammensetzung des Pansensafts entstanden nach der Verabreichung von $NaHCO_3$ + Glukose und $NaHCO_3$ + Fruktose, waren gleichartig, mit Ausnahme davon, dass der pH-Wert im Pansen nach Fruktose niedriger war.

In einem anderen Versuch wurde der Einfluss auf das Blutzuckerniveau und die Verdauung im Pansen durch Melasse (Sacharose), beziehungsweise Molke (Laktose), per os gegeben, verglichen. Melasse

bewirkte eine deutliche Erhöhung des Blutzuckergehalts 6, 12 und 24 Stunden nach der Verabreichung, während das Blutzuckerniveau zu denselben Zeiten nach der Molkeverabreichung nur unbedeutend höher war. Die Melasse umwandelte sich schnell im Pansen und die Molarproportionen von den dabei gebildeten flüchtigen Fettsäuren wurden nicht beeinflusst. Die Molke wurde erheblich langsamer als die Melasse abgebaut und unter Bildung von bedeutend mehr HAc und HBu. Dies wird folgendermassen gedeutet: das Molkekonzentrat muss einen potential positiven Einfluss aus das Fettgehalt der Milch haben.

SAMMANFATTNING

Effekten av peroralt tillförda lättlösliga kolhydrater på våmdigestion och blodsockerhalt hos mjölkkor.

Efter peroral tillförsel av 10 %-ig $NaHCO_3$-lösning + glykos erhölls en större blodsockerstegring än om enbart glykos gavs. Detta tyder på att oesophagealrännereflexen kan utlösas även hos vuxna nötkreatur. En del av den tillförda glykosen överfördes därigenom sannolikt direkt till löpmage — tunntarm utan att först omvandlas till flyktiga fettsyror i våmmen. Blodsockerhöjningen var difasisk med den första stegringen efter 1 och 2 timmar och den andra efter 12 och 24 timmar. Sex timmar efter givan förelåg ingen höjning. Efter tillförsel av $NaHCO_3$ + fruktos fick de flesta korna kraftig diarré och blodsockervärdet påverkades inte. De förändringar som uppstod i våmvätskans sammansättning efter tillförsel av $NaHCO_3$ + glykos och $NaHCO_3$ + fruktos var likartade med undantag av att våm-pH var lägre efter fruktosgivan.

I ett annat försök jämfördes inverkan på blodsockernivå och våmdigestion av melass (sackaros) och vassle (laktos) givna per os. Melass gav upphov till en tydlig ökning av blodsockret 6, 12 och 24 timmar efter tillförseln, medan blodsockernivån endast hade stigit obetydligt vid samma tidpunkter efter vasslegivan. Melassen omvandlades snabbt i våmmen och molarproportionerna av de bildade flyktiga fettsyrorna påverkades inte. Vasslen bröts ner betydligt långsammare och under bildning av betydligt mer HAc och HBu än vad som gällde för melass. Detta tolkas så att det använda vasslekoncentratet bör ha en potentiellt positiv inverkan på mjölkens fetthalt.

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